Competence development of STE(A)M educators through online tools and communities

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D21: Guide for STE(A)M education policy makers

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Abstract:	The STEAMonEdu project has been focused on STE(A)M related policies throughout its life thanks to the engagement of the education stakeholder Community of Practice, group discussion and talks, local and international events, collection, sharing, evaluating, promoting and supporting in creating, and assessing of policy recommendations. Tools, results and outcomes could bring further from STEAMonEdu project at all levels.

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Abstract

The STEAMonEdu project has been focused on STE(A)M related policies throughout its life thanks to the engagement of the education stakeholder Community of Practice, group discussion and talks, local and international events, collection, sharing, evaluating, promoting and supporting in creating, and assessing of policy recommendations. This document is providing an overview of STE(A)M related policies at European level, identifying, and evaluating project results under the light of policy with the aim of showing which tools, results and outcomes could be bring further from STEAMonEdu project at all levels.

1   Introduction

This document is aimed at providing an overview on European policies on STE(A)M related topics as a background scenario where the STEAMonEdu project took place with its results, outputs, and activities (chapter 3). A both quantitative and qualitative analysis of the results (chapter 2), outputs and feedback received from participants and stakeholders are presented to depict the impact of the project within policies (chapter 4), identify policy recommendations for educators, learning providers and policymakers and, finally, map them on the STE(A)M educators' competence framework developed within STEAMonEdu project (chapter 5). A closing remark to link project outputs and results within a policy perspective is also provided (chapter 6).

1.1   Summary of the project

The project aims to increase the adoption and impact of STE(A)M education by investing in the community of stakeholders and the professional development of educators.

The approach of the project is to nominate educators as the pillars of implementation of STE(A)M education policies and support their professional development either by blended training or by their participation in a community of practice. The training programme and the exchange of experience, collaboration and creative work of the community are supported by an online peer learning and crowdsourcing platform.

As a result of research conducted by the consortium, the STE(A)M education framework, Educator's profile and Self-Assessment STEAM have been developed, including competences, policies, methodologies, learning objects, etc.

These findings have the core elements of the design of the training curriculum for STE(A)M educators, addressing the training programme: the MOOC "STE(A)M education for educators: Design, orchestration and implementation of STE(A)M education" and the blended training. The MOOC is available to everyone interested in the topic, and more than 500 people have enrolled. Also, 50 MOOC graduates have been selected for the blended training to focus their attention on the production of learning activities templates, STE(A)M education projects and policies to strengthen their competences in adopting and further develop and promote STE(A)M education at both local and national level.

The project has a bottom-up participatory approach when delivering:

- The **online community** of educators, collecting good practices and STE(A)M education policies.
- The **STE(A)M education framework**, including the body of knowledge, template curricula and learning activities, with a focus on diversity.
- The **STE(A)M competence framework**, detailing the competences needed to design and implement STE(A)M education activities (STEAMComp will specialize DigCompEdu with STE(A)M-specific competences).
- The **STE(A)M educator profile**, designed on the principles of ESCO (European multilingual classification of Skills, Competences, Qualifications and Occupations).

- The training programme, targeted to STE(A)M educators and delivered online on a [MOOC](#) (with OERs contents) and [blended training](#).
- The guide of STE(A)M educational **[practices](#)**
- The guide on STE(A)M education **[policies](#)**
- The STE(A)M **policy influence toolkit**
- The Guide for **STE(A)M education policy makers** (Policy recommendations)
- The STE(A)M readiness **self-assessment online tool** for educational organisations that implement STE(A)M education policies, that will implement or expand SELFIE.

1.2 STEAMonEdu Partnership

1. [Computer Technology Institute and Press "Diophantus" (CTI),](#) Greece (Coordinator)
2. [ALL DIGITAL](#), Belgium
3. [Stati Generali dell'Innovazione (SGI),](#) Italy
4. [Helliwood/21CCC](#), Germany
5. [EOS Foundation](#), Romania
6. [Colectic](#), Spain
7. Regional Directorate of Primary and Secondary Education of Western Greece/Ministry of Education Lifelong Learning and Religious Affairs, Greece.

1.3 STEAMonEdu direct impact in numbers

- 705+ members of the STE(A)M education stakeholder Community of Practice

- 126+ practices collected within the STE(A)M education stakeholder Community of Practice

- 52+ policies gathered within the STE(A)M education stakeholder Community of Practice

- 229 teachers successfully completed the STEAMonEdu MOOC course

- 58000 posts in 20 forum topics within the STEAMonEdu MOOC

- 27 trained teachers successfully completed the STEAMonEdu blended course

- 26 policies created within the STEAMonEdu blended course

2   Methodology

Desk research on European policies is at the basis of the contents shared and analysed within chapter 3. The criteria of selection of the policies have been set on: 1. STEM moving into STE(A)M and the specific focus on gender balance issues; 2. Teaching methodologies and the focus on schools within STE(A)M approaches promotion; 3. Looking forward policies on Education.

A critical analysis of the practices, policies, inputs, and discussions shared by member stakeholders within the STEAMonEdu Community of Practice is at the basis of the discussion on chapter 4 in combination with considerations, overview and expertise from project partners. Additionally, group discussion techniques, comparison of national needs, provisions, programmes and educational systems and insights and evaluations collected during the national events and final event of the STEAMonEdu project have informed both chapter 4 and 5.

3 STEM and STE(A)M within European Policies

Modern societies, especially within the EU, have started being focused on sustainability, putting under the light the climate change challenge. The green transition requires citizens with green and entrepreneurship skills to be developed in combination with core skills and, of course the transversal, or soft, skills. Within this scenario, digital competences are also part of the skills European citizens should have for their everyday life. This combination of skills is supported by European policies, through both sectorial and transversal policies, such as the Green Deal, the EU Skills Agenda and the Digital Compass.

During the STEAMonEdu day within the ALL DIGITAL Summit, held on 14th October 2021, EU policy officer **Anusca Ferrari**, DG EAC, through her keynote speech shed light on the EU objectives and initiatives: "We set STEM as a priority for cooperation projects in Higher Education in the Erasmus+ 2021 Work Programme. [...] Only 1 in 5 young people in Europe graduates from STEM tertiary education, and we have less than 2 million of STEM graduate in the EU every year. Even if we try to promote an inclusive approach to STEM education, actually we know that women are strongly under-represented in the sector: 1 in 3 STEM graduate is a woman. It is even worse when we look at ICT studies where we have 1 in 5 ICT graduate that is a woman."

3.1 STEM, STE(A)M and gender balance policies

The EU SKILLS PANORAMA 2014 focused on STEM skills highlighted an increase of 12% of occupation within STEM from 2003 to 2013 at a time when total employment grew by only 4%. It has been three times as much as total EU-28 employment and in 2013 it was at 7% of all jobs. At the same time, employers were reporting difficulties in finding 'job ready' candidates who have the needed skills, soft skills included. From 2015 to 2025, all occupations are expected to grow by 3% and STEM professional and associate professional occupations are expected to grow respectively by 12% and 7%.

STEM and STE(A)M have started being recognised as an integrated approach to facilitate the development of the clusters of skills mentioned within the education programmes at all levels within Europe with a specific focus on female access to STEM and STE(A)M careers. These are two interlinked aspects that have the aim of guaranteeing well equipped European citizens for modern and future jobs on one side and facilitate the female access to further education, jobs, and careers on the other.

The increase demand, and expected demand, of STEM based careers has stimulated the STEAMonEdu consortium in being focused on educators ability to train the next generation of professionals by developing a dedicated and tailored training programme, competence framework and tools to set, train, evaluate and bring forward the readiness of both educators and learning centres/ educational providers.

In the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *Rethinking Education: Investing in skills for better socio-economic outcomes,* (COM/2012/0669 final) has introduced the relationship between STEM within society and the gender balance: "Greater efforts must now be made to highlight STEM as a priority area of education, and increase engagement at all levels. Although broad challenges are well known, such as the need to make it more attractive to females, it is also now important to increase understanding of the career pathways followed by STEM graduates".

Furthermore, the discussion within the Higher Education programmes raised the challenges that Europe's higher education systems faces. In the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee

of the Regions, *Renewed EU Agenda for Higher Education,* (COM(2017)247final), it is pointed out "A mismatch between the skills Europe needs and the skills it has: many parts of the EU are experiencing shortages in certain high-skill professions, both in terms of qualifications and the quality of the associated skills. At the same time, too many students graduate with poor basic skills (literacy, numeracy, digital) and without the range of transversal skills (problem-solving, communication, etc.) they need for resilience in a changing world." The Communication further explores ways of tackling skills mismatches and promoting excellence in skills development with direct reference to STE(A)M education. More specifically: "Addressing Europe's high-level skills needs requires action. First, more people need to be attracted to the fields of study that prepare students for jobs where shortages exist or are emerging. In many EU Member States there is unmet demand for graduates in science, technology, engineering, (arts) and maths (STE(A)M) fields, medical professions and teaching. Second, all students in advanced learning, irrespective of discipline, need to acquire advanced transversal skills and key competences that will allow them to thrive. High-level digital competences, numeracy, autonomy, critical thinking and a capacity for problem-solving are increasingly crucial attributes". Which confirms the modern scenario of skills development needed at European level and the programmatic relationship with STEM and STE(A)M considering also the gender balance, especially within the working environment.

Also the COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning, (2018/C 189/01), underlines the competence needs due to the technological infrastructure and service-based modern societies, and the current overall level of knowledge and skills citizens and educators have. Competence requirements have changed with the result that technologies currently cover a crucial role in society and entrepreneurial, social, and civic competences have become essential for citizens to adapt to change.

The COUNCIL RECOMMENDATION of 19 December 2016 on Upskilling Pathways: New Opportunities for Adults reports data collected by the Organisation for Economic Cooperation and Development (OECD), the Programme for International Student Assessment (PISA) or the OECD Programme for the International Assessment of Adult Competencies (PIAAC) highlighting the lack of basic skills among both teenagers and adults across Europe, especially in reading, maths, and science, although girls have better skills competences in reading and writing rather than in science and maths. Differences that might be linked with many factors, such as the cultural context, bias, level and understanding of competitiveness, lack of role models and so on as depicted in *Girls' career aspiration in STEM* by the Directorate-General for Education, Youth, Sport and Culture in 2021.

Whereas the Commission is supporting the EU STEM Coalition to contribute helping and promoting the development of new higher education curricula for engineering and ICT based on the STE(A)M approach, bringing together academic and non-academic actors in STEM sectors.

According to the latest Eurostat data, only one in five young people in Europe graduates from STEM tertiary education, less than two million STEM graduates every year in the EU. And only one in three STEM graduates is a woman. When refining the sector in ICT subjects, it drops down to one in five. With the aim of supporting gender balance issues, the Commission has set up the European Institute of Innovation and Technology (EIT) that is promoting the Girls go Circular initiative with training activities for female students at secondary education.

The emerging focus on gender balance has been extensively discussed during the STEAMonEdu events, especially at local event, raising the awareness in structuring and promoting specific activities and policies, especially at local level. In Spain, for instance, in November 2021, the Ministry of Education and Vocational Training has set the STE(A)M Alliance for female talent to promote scientific vocations in girls and young people, involving public and private organizations.

3.2 Schools and teaching

Related specifically to the schooling system, the [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](), titled *School development and excellent teaching for a great start in life* (COM(2017)248final) refers to STEM education, stimulating the exchange of best practices and promoting cooperation of higher education, research, businesses with schools with the Erasmus+ funding. In fact, the Erasmus+ Programme Guide, which is the Union programme for education, training, youth, and sport has included as a priority "Promoting the development of national STEM strategies; developing partnerships between schools, businesses, higher education, research institutions, and wider society; promoting effective and innovative pedagogies and assessment; promoting the STE(A)M approach to education through interdisciplinary teaching of STEM in cultural, environmental, economic, design and other contexts, with the involvement of all academic discipline".

More specifically, the [Erasmus+ Programme Guide](), version 2, based on REGULATION (EU) No 1288/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2013 establishing 'Erasmus+': the Union programme for education, training, youth and sport and repealing Decisions No 1719/2006/EC, No 1720/2006/EC and No 1298/2008/EC, provides guidelines for the implementation of the Erasmus+ Programme and, within this context, to review the STEM curricula to enhance the attractiveness of STEM by adopting a STE(A)M approach via the development and implementation of national STEM strategies.

Likewise, while addressing the priority of *Tackling skills gaps and mismatches* there is a specific reference to STEM and STE(A)M: "developing, testing and implementing flexible and modular course design (part-time, online or blended) and appropriate forms of assessment; d) increasing attractiveness and reforming curricula for STEM with a STEAM approach including real-world applications, inquiry-based and ICT-enriched learning, collaborative practices, including university-business cooperation".

Referred to teaching methodologies with an integrated approach, looking forward to STEM and STE(A)M, in the [COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning,]() (2018/C 189/01), the Commission recognises that "Learning methodologies such as inquiry-based, project-based, blended, arts- and games-based learning can increase learning motivation and engagement. Equally, experimental learning, work-based learning and scientific methods in science, technology, engineering and mathematics (STEM) can foster development of a range of competences". It also underlines the importance on adopting different types of learning approaches and methodologies, such as inquiry-based, project-based, blended, arts- and games-based learning which increase engagement, motivation and learning itself and "taking into account their link to the arts, creativity and innovation and motivating more young people, especially girls and young women, to engage in STEM careers".

European policies are increasing the focus on STE(A)M education adoption within formal and non-formal training curricula at all levels and on the gender balance in both education and working environment. STEAMonEdu outputs, especially the competence framework, training programme, the Community of Practice and readiness evaluation tool provide practical tools and assets to tackle these issues and consistently contribute to solving them at European, national, and local levels. Additionally, the progressive adoption and circulation of these tools will also contribute to the overall discussion and awareness at all levels of the potential additional needs and further actions to adopt, ameliorate and localised the developed tools.

3.3   European policies on Education

STE(A)M education can be interpreted as an approach to practically translate the green and digital transition within the everyday lives and professionally to enhance sustainable competitiveness at economic level, ensuring social fairness, and building on resilience, in line with the Digital Compass.

The Digital Compass, presented on 9th March 2021, is the vision of the European digital transformation by 2030. It identifies four cardinal points: Skills, Infrastructures, Business and Government focusing on gender convergence, with the aim of educating at least the 80% of the population to the Basic Digital Skills, providing a climate neutral technological infrastructure everywhere engaging companies within this process and facilitating the switch of the public services for citizens into digital tools and platforms. In September, the Commission published a proposal for a Decision by the European Parliament and the Council establishing the 2030 policy programme "Path to the digital decade" (COM(2021) 574 final) transposing the Digital Compass into a legislative instrument.

The STEAMonEdu outcomes and results can support the aspects highlighted within these policies detailing the tools and further needs, also in terms of policies, relevant to satisfy the aims set at European level.

Within this scenario, the European Education Area operates as the point of reference for Union Member States with the focus on: 1. the quality in education and training; 2. the inclusion and gender equality; 3. in building resilient and forward-looking education and training systems in line with the approach of the Next Generation EU and the COVID-19 recovery plan, facing the digital and green transitions; 4. supporting teachers and trainers (with the European guidance for national career frameworks and the European Innovative Teaching Award); 5. Higher Education programmes for upskilling; 6. Making sure that education has a Geopolitical dimension.

The vision for the education profession within the European Education Area is one of the highly competent and motivated educators who can benefit from a range of support and professional development opportunities throughout their varied careers. There is a need for a highly competent, enthusiastic, and committed professional workforce. And the first aim is to overcoming teacher shortages which is an issue that many EU countries are facing, either within STEM or when addressing learners with special needs.

The Digital Education Action Plan (2021-2027), *Resetting education and training for the digital age* of the European Commission clearly set as strategic priorities to "foster a high-performing digital education ecosystem we need digitally-competent and confident educators and education and training staff" where STEM disciplines are included, "to enhance digital skills and competences for the digital age: supporting the provision of basic digital skills and competences from an early age" and "promote advanced digital skills development; Digital Opportunity traineeships and encourage" a more consistent participation of women in STEM education practices and so foster gender equality.

This objective works nicely in combination with the 2020 European Skills Agenda that has included STEM as one of the 12 actions identified to carry on. It is quite evident that these actions have the aims of contributing to develop skills for jobs in a green and digital economy, which brings us in considering STEM within the modern context.

Looking forward, finally, the European Commission is funding a European Digital Education Hub to support cross-sector collaboration and exchange at regional, national and EU level in digital education with the aim of supporting Member States in their digital education strategies and efforts.

These policies address STE(A)M education from the competence perspective in stimulating Union Member States to include within their curricula STE(A)M subjects and approaches for educating the future generations for a more inclusive and sustainable modern environment.

Within these recent policies, initiatives, and infrastructure STEAMonEdu outputs and results can provide at European level, a concrete example of the types of tools and actions that could be developed and delivered to satisfy the set aims and, also, a concrete set of tools, environment and data to build upon further tools and actions at all levels investigating other gaps and needs and promoting further policies development.

4   Inputs from the STEAMonEdu Community of Practice

This section is specifically focused on the inputs collected by the STEAMonEdu partners in the Community of Practice and the training programme (MOOC and the blended training).

The Community of Practice has been set up according to a shared strategy based on an initial recruitment of educators, researchers, policymakers, education authorities, career consultants, content producers active within education at any level, plus communities (Scratch, CodeClub, CoderDojo etc.) and members from in the filed associations. Within the Community of Practice there had been activated discussions within the forum on STEM and STE(A)M related topics to support partners in gathering relevant data to be translated in practical inputs for the project developments and forward-looking aspects to be addressed.

The training programme has been developed according to the identified needs and have been related to the competence framework developed and split in a MOOC and a blended course. Within the blended course a specific focus on policy, especially on how to write policies, have been included stimulating the reflection, and practice, in writing policies in general as part of the learning outcomes of the module dedicated on policies.

4.1   Inputs from the Community of Practice

During the STEAMonEdu project a total of more than 700 members have joined the education stakeholder Community of Practice where to share practices, policies, inputs, and insight on STE(A)M approaches, challenges, and experience. The audience covers a variety of teachers and educators at all levels, policy makers, education authorities, career consultants, contents producers and so on within the education sector. Part of this audience took part at the stakeholders' events and the training programme developed within the STEAMonEdu project.

Insights shared within members of the Community of Practice highlight the overlapping and ubiquitous definitions of STE(A)M education. Despite the emergence of STE(A)M as a pedagogical approach for enhancing students' creativity, problem-solving skills, and interest in STEM fields, the definitions and purposes of STE(A)M education remain vague. The fragmented interpretation could be motivated by different understanding of the STE(A)M approach, the many interpretations and practical understanding of the liberal Arts and it could be affected by the different national educational systems.

4.2   Inputs from the training programme evaluation analysis

The training programme has been evaluated with a pre-MOOC, post-MOOC and post-blended training surveys, engaging with all participants. The average of responses differs due to the limited offering in participation of the blended course.

The MOOC has been attended primarily by Greek and Romanian teachers and within the 170 answers for the pre-MOOC and 261 for the post-MOOC. Although the numbers differ, the overall demographic is pretty the same with more than 80% of responders was in the 35-54 age range with more than 80% women. Almost 70% of respondents holds a Master level qualification and overall, around the 85%

operates within formal education, the majority in Secondary Schools, then Primary and, finally, Pre-school levels. Within this community of respondents, almost half of teachers have more than 20 years of experience and another third more than 10 years which suggests that most of participants are long experienced teachers within formal education with a high level of qualifications.

From a critical analysis perspective of the evaluation of the pre-MOOC responses, teachers have expressed their expectations to acquire new skills, knowledge, and resources (above 90% each) that has been satisfied (from the post-MOOC evaluation data), and additionally to get in touch with experts and collaborate with peers (above 70% each) that hasn't being satisfied within the MOOC due to the nature of the MOOC itself that doesn't provide collaborative features.

This scenario suggests that teachers are willing to adopt new methodologies in teaching and investing effort to gain sources (knowledge and skills included as overall sources) to change and improve their everyday working activity in practice but also need to exchange, discuss, gain feedback from both peers and experts.

Comparing the perception of participants regarding to the ability to change aspects within their organisation and affecting regional and national policies, seems to be more challenging after the MOOC experience. We should remind that this audience operates within formal education, and it would be worth to refer to the two countries where most respondents are from: Greece and Romania. Both countries have a centralised educational system which might give the perception to teachers that the school decision making has a top-down approach only. This perception is higher after the MOOC training, probably due to the deeper knowledge gained and understanding on the impact and implications of adopting STE(A)M education approaches.

Teachers have also clearly expressed the need to have practical insights, examples, experience sharing in a non-formal setting other than theories and concepts to consider when dealing with education in general. It is in line with the need of looking for sources, especially ready to use ones and inspiration in general and with sharing and discussion between peers to get further details on doubts, concerns and how to overcome issues.

In fact, those that have attended the blended course, a total of 45, have generally expressed their satisfaction (93% of positive evaluation) on the exchange with the experts and the live sessions included where peer collaboration was also promoted. Within the blended course had been covered additional topics to the MOOC, including policy creation and promotion. It is then worth to mention the lower confidence perceived by teachers at the end of the blended course which might suggest that there's an overall lack of confidence in writing policies and, more generally, apply a policy mindset within the schooling systems.

4.3 Inputs from the policies developed by participants of the STEAMonEdu blended course

As part of the blended training programme, participants have produced policies at local and regional level. From the evaluation and analysis of them, there are some common aspects that can be predictable, such as the need for specific training on how practically translate STE(A)M approaches,

and the overall suggestion to raise the awareness on STE(A)M education and its approach at all school levels. Additionally, some policies are focused on encouraging building and nurturing more communities of practice and interpret them as a learning and collaborative tool for multidisciplinary integration to foster the holistic nature of the STE(A)M.

It is worth to mention the policies proposals developed from participants that already have introduced and experienced STE(A)M educational approach. In these cases, the policies are focused on suggesting the development of career paths; on the adoption of STEM subjects as a neutral field for cultural inclusion and integration; the revision of curricula moving from a subject based approach into a holistic one; the development of technological laboratories designed for STE(A)M activities; and the proposal of using cultural heritage as a natural context for STE(A)M projects.

5   Policy Recommendations

The main project outcomes, the STE(A)M educator competence framework, the training programme (the MOOC and blended training), the Community of Practice, the STE(A)M readiness self-assessment online tool, STE(A)M education framework, including STE(A)M body of knowledge, template curricula and learning activities have been designed and developed through a bottom-up approach engaging with stakeholders, educators, educational managers that have joined the STEAMonEdu Community of Practice.

The impact of COVID-19 has stressed on one hand the relevance of innovative approaches and methodologies within education, especially the schooling system, asking for higher and wider development of digital competences of educators and the availability of educators in terms of time frame to allocate in upskilling and reflection on the other hand.

Project partners elaborated two sets of recommendations for training providers and policy makers adopting the STE(A)M educator competence framework developed within the STEAMonEdu project. As one of the main outcome, the 5 perspectives elaborated can support the identification and description of the recommendations with the aim of promoting and supporting transfer and upscaling of STEAMonEdu outcomes and key results in the education sector across Europe. Recommendations are based on project outcomes and results and the experience and expertise of project partners in the field.

5.1   For education and training providers

STEAMonEdu project aims are focused in promoting innovative and cross-disciplinary approaches to STE(A)M teaching in education through the development of a STE(A)M educator competence framework, a training programme formulated as a MOOC and a blended course, and a Community of Practice with educational stakeholders.

These components are at the core of the STEAMonEdu recipe to foster the adoption of STE(A)M approach within education looking forward to support upskilling of teachers and educators within formal, schooling, and non-formal educational organisations. With this specific aim, has been developed and adopted Open Educational Resources in diverse European languages and has been started the revision and strengthen of the professional profile of the teaching professions.

The work of the teachers in schools across Europe has the same mission but it differs massively on how it is implemented, depending on national legislation, regional, and often local legislation, and on the autonomy that each school institution might have due to the educational system. The autonomy of the formal education sector is of outmost importance and with the following recommendations STEAMonEdu project partners do not want to undermine it.

1. **Adoption of the STEAMonEdu educator competence framework**

In line with European policies highlighting the relevance of further develop training curricula at all levels (EU SKILLS PANORAMA 2014, European Education Area), adopting a lifelong learning educational mindset and upskilling scenarios for teachers (COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning, Communication from the Commission to the European

[Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](), COM(2017)248final, [Digital Education Action Plan (2021-2027)](), and, finally, facilitate the development of an educational environment where the next generation can tackle the current challenges, in line with the Green Deal and Digital Skills Agenda, and also to support gender equality within education and, as a further impact, within the working environment ([Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions]() (COM/2012/0669 final), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](), COM(2017)247final, [European Skills Agenda]()).

In Germany, Italy, and Spain, to mention project partners countries, the local educational policy levels differ to each other. In Germany, for instance, each federal state has its own policies and recommendation and at national level there is the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder which provide recommendations only as general guidance. Thus, the STEAMonEdu educator competence framework clearly set what competences are needed and which area of improvement educators, teachers and school managers should invest in. What emerged from the STEAMonEdu projects is the demand from stakeholders to educational institutions and their staff for their readiness of change towards the digital transformation. The STEAMonEdu educator competence framework responds to this demand perfectly because it has been developed based on DigComp framework for education. Additionally, the training programme has been designed based on the STEAMonEdu educator competence framework.

2. **Invest in teachers', educators' and educational staff training adopting the STEAMonEdu programme (MOOC and the blended training)**

STE(A)M education and approaches are becoming more popular and widely explored and adopted especially within the schooling system thanks also to the European policies recently published where STEM and STE(A)M is specifically addressed ([EU SKILLS PANORAMA 2014](), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions]() (COM/2012/0669 final), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](), COM(2017)247final, [COUNCIL RECOMMENDATION of 19 December 2016 on Upskilling Pathways: New Opportunities for Adults](), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](), COM(2017)248final, [Erasmus+ Programme Guide](), [COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning,]() (2018/C 189/01) [Digital Education Action Plan (2021-2027)](), [European Skills Agenda]()). The increase of the demand stimulates the request of training provisions. The training pilot conducted during the STEAMonEdu project can be considered as a high-level training programme in terms of quality and an effective programme to supporting teachers in developing skills, knowledge and feeling comfortable when delivering STE(A)M based session in class.

Sub-recommendations

2.a Time planning and scheduling

Teachers would need dedicated time to commit the required effort to accomplish the training programme. It should be an investment from both the teacher and the organisation supporting the upskilling.

2.b Language preferences

Educators would benefit from having the chance to take part at the training programme in their first language. It would decrease the time and effort, especially at cognitive level, spent in translating and language doubts and enhance the learning gains.

2.c Microcredentials approach

Exploring short learning programmes and award with micro-credentials approach would facilitate the spread of STE(A)M education especially during this challenging pandemic period.

3. Nurture STE(A)M Community of Practice

The direct involvement of stakeholders in populating the platform and consequently the community is a challenging and at the same time enriching practice. Participants are continuously encouraged to actively engage and contribute to the development of the community itself by sharing their practices, experiences, and providing feedback to peers, in line with the European policy highlighting the relevance in sharing best practices and promote cooperation (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)248final).

The STEAMonEdu Community of Practice proved both a platform where educators can either meet experts and peers to receive feedback on their practices and policies and to get inspired and gain from others' practices, policies, and experiences and share and exchange best practices at any education levels and independently from the field. The co-generation of value made by the collaborative activities and exchange has been an added value, useful for creating a high level of participation and support learning.

4. Support cross-disciplinary synergies within the educational organisation and between organisations

Following the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (COM(2017)248final), the bottom-up approach adopted in STEAMonEdu project can provide a trusted example of collaborative design, creation and sharing of educational scenarios, that could be brought forward as a more systemic collaborative dynamic between teachers and educators with different backgrounds and/or organisations focused on any of science, technology, engineering, arts, and mathematics. Thanks to the dialogue with the stakeholders, it is evident the difficulty for educators to cover confidently the overall STE(A)M spectrum. According to the Digital Education Action Plan (2021-2027) and European Education Area, the new scenario should facilitate the cooperation between educators with different Higher Education programmes, qualifications, supporting cross-disciplinary synergies with external organisations to enhance a more practical sense of real-life environments and issues to

learners, in line with the STE(A)M approach. A broad partnership with stakeholders closes to the local community, companies, and organizations active at a regional level, could offer future STE(A)M-related model careers to students tackling societal needs.

These aspects are also supported from studies that have been collected within the desk research carried out during the STEAMonEdu project and shared within the community members [deliverable 8.1 reference]. It has been evaluated the lack of confidence educators have in delivering science materials and find difficulty in gaining students' interest to study science subjects. There is also evidence for a similar association between confidence, anxiety, and efficacy with teacher effectiveness. Thus, STEM might be necessary for technological progress, but without the Arts it is impossible for students to reach their full potential in applying creative thinking, source from imagination and exercise both sides of the brain at once.

5. Support the development of dedicated STE(A)M infrastructure

From the [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](#) (COM(2017)248final), that highlights the relevance in facilitating cooperation and exchange of best-practices, a creation of a dedicated setting as a laboratory where hosting STE(A)M based lessons. This facility could enhance the adoption of STE(A)M approaches and methodologies and it could be both within the school infrastructure and outside it in collaboration with other educational institutions, local authorities, NGOs, SMEs, and the public and private sector related to STE(A)M disciplines. Within STEAMonEdu stakeholders within the Community of Practice have developed local policies focused in developing such a dedicated environment and facility.

5.2 For educational policy makers: local, regional, national, European

The following recommendations specifically target policy makers in the field of education and training, on local, regional, national, and European level, depending on their competences.

1. Develop a shared and common definition of STE(A)M education harmonizing the meanings and perspectives

STE(A)M education is increasingly present within European policies, and at cascade at national and local ones, and overall, there's a fragmented understanding of its meaning and practical translation. The STEAMonEdu project has contributed to stimulating the discussion within the Community of Practice and promoting a definition knowledge within the training programme aiming at creating a common ground where to operate and further build on within. An acknowledgment of a shared and common definition would facilitate the general understanding of the field and support the adoption within education at all levels.

2. Promotion of the STEAMonEdu educator competence framework

The increasing need of equipped teachers to support current educational needs of the new generation of professionals, as per the recent European policies ([COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning](#), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](#), COM(2017)248final, [Digital Education Action Plan (2021-2027)](#)), may suggest an inner

need in identifying a dedicated competence framework. The STEAMonEdu educator competence framework can satisfy this need by providing a framework evaluated by experts across Europe and tested during the pilot training programme. At European level as the STE(A)M competence framework for educators and teachers, at national levels to lead and facilitate the review of the national programmes for both educators and students, at regional and local levels (especially in those countries where the autonomy in educational management stands to the school) to support educational institutions in adopting STE(A)M approaches.

3. **Support the development of an accrediting certificate of STE(A)M related skills for educators**

From the analysis of the evaluation of the STEAMonEdu training programme, teachers have expressed an interest in acquiring a certificate that could be spent at national level to improve their professional position. At regional and national level its relevance would support the recognition of the competences and an improvement of teachers' role. At European level it would support mobility and standardisation processes within STE(A)M education.

4. **Organise and facilitate co-design development of policies between policymakers and educators**

As already highlighted within the European policies (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)248final), collaborative activities should be promoted to support educators and stakeholders within the field.

The bottom-up approach of STEAMonEdu project, especially within the Community of Practice, has showed the benefits of exchange, inspiring, provide feedback and collaborate especially when elaborating policies. The combination of backgrounds and everyday experience would support the flourishing of policies focused on STE(A)M which are quite lacking currently across Europe. At local and regional level, it would support implementation of new initiatives and facilitate innovation. At national level it would increase the liaison between teachers' needs and national overview, infrastructure and decision making (especially for centralised decisions and directions). At European level it could identify common needs and facilitate studies and mapping comparing different educational levels between formal and non-formal education.

5. **Test and harmonise the evaluation processes and systems for both students and educators**

STE(A)M approach within education is a holistic based methodology of teaching that could clash with evaluation processes and systems based on the measurement of the knowledge of one subject. At the opposite, it would be worth to introduce the focus on the evaluation of the learning process and the development of competences. For example, within the Italian schooling system is adopted a test methodology and process called "INVALSI", introduced in 2017 by the law D.lgs 13 Aprile 2017, n. 62 - *Regolamentazione delle prove INVALSI e degli Esami di Stato*, that doesn't match with the cross-disciplinary approaches in learning. This could prevent teachers in extensively applying STE(A)M approaches in class to avoid disappointments during the exams for both students and teachers. At

national level it would support both centralised educational systems and decentralised ones indicating clear directions and borders of actions for regional and school decision taking.

6. Develop and support awareness raising campaign on STE(A)M related topics

From the feedback received from stakeholders it has been expressed the underneath need of a wider understanding of STE(A)M approach and related topics which could be spread through awareness raising campaigns. They could be targeted also to parents and the wider community as pointed out by STEAMonEdu community members. They could be organised as informative campaigns, inspiration events and awards like the STEAMonEdu Photo Contest that has been evaluated by teachers as an excellent chance to get inspired by the others and their practices. It could benefit at all levels, at local and regional targeting clusters of schools and non-formal educational organisation, at national level liaising and identifying national messages and challenges, and at European level to promote widely STE(A)M education implementing European policies.

7. Fund and sustain mentoring events for both educators and education managers and promote STE(A)M ambassadors

According to the identified need of equipped educators to face current challenges and enhance education ([COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning](#), [Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions](#), COM(2017)248final, [Digital Education Action Plan (2021-2027)](#)) additional activities to support the learning process could be provided. As a more tailored support, educators and educational managers would benefit from having a dedicated session(s) with STE(A)M experts in facilitating the adoption of STE(A)M approaches within their classes and schools. Participants of STEAMonEdu training programme have shared that it would have been beneficial to have more occasions within the blended training to discuss, review and further develop their STE(A)M activities. It would be beneficial at both local and regional level involving national and European ambassadors facilitating diversity within exchange and peer support.

8. Development of STE(A)M national policies and frameworks

As noticed during the development of the STE(A)M Influence Toolkit, a general lack of national policies would suggest promoting the development of dedicated ones and, additionally, frameworks focused specifically on STE(A)M education. As we have seen, some of STEAMonEdu partners' countries are lacking national STE(A)M policies or strategies, which is a major obstacle for the implementation of STE(A)M in education. In this sense, the STEAM education framework produced by our project can be used as a tool to support this work at national level.
An initial step is recently being taken by the Spanish Ministry of Education and Vocational Training in November 2021 with the STE(A)M Alliance for female talent to promote scientific vocations in girls and young people, involving public and private organizations. The aim would be to promote the training of teachers in STE(A)M, the creation of a quality seal for companies and entities of the Alliance to develop actions to promote these disciplines, as well as educational centers that incorporate the new focused Professional Guidance Program in STE(A)M. In addition, it will promote students' Vocational Training cycles linked to STE(A)M develop practical workshops at Primary, ESO and Baccalaureate level of education.

9. **Development of a STEM/STE(A)M Education Hub**

Looking forward the increasing need and demand of STEM/STE(A)M education, a centralised and common digital platform would support the access of high-quality training activities and tools tailored to educators of all levels and backgrounds.

5.3 According to the 5 areas of the STE(A)M educators' competence framework

The recommendations elaborated can be mapped within the STE(A)M educators' competence framework developed within the STEAMonEdu project with the aim of identifying per each area potential actions to pursue and to suggest the adoption of this framework for policies.

Figure 1: Overview of the Competence Framework for STE(A)M Educators

Educator as teacher-trainer-tutor perspective includes all the required educators' competences during the implementation of an educational procedure that helps students learn. It includes competences related to Pedagogy, Content Knowledge, Instruction, Use of content and tools, Feedback and Assessment and Learner empowerment.

Within this dimension, recommendations n. 2 (the training programme) and n.3 (the Community of Practice) fits well as learning experiences, occasions, and environment to develop and further enhance competences, knowledge and tools needed when delivering training.

Educator as a learning designer and creator perspective includes all the required educators' competences related to planning, preparing, and developing (a) educational procedures, (b) learning activities and (c) content that are needed in the different phases and settings of STE(A)M-related learning processes. In addition, it features all the supporting competences which aim to boost and facilitate learner development regarding STE(A)M competences.

In this dimension recommendations n. 1 (the actual competence framework) and n. 10 (evaluation processes and systems) complement the overview of the role covered.

Educator as orchestrator and manager perspective includes all the required educators' competences related to managing and orchestrating (a) the educational procedures, (b) the content and the digital technologies in teaching and learning (c) the lab and its equipment and (c) group of students or/and other educators during collaborative learning activities.

Recommendations n. 5 (the development of dedicated STE(A)M infrastructure) and n.12 (Tailored mentoring activities) have a significant impact within this dimension.

Educator as community member perspective includes all the required educators' competences related to interacting and engaging with institutional, business, or other STE(A)M-related communities and to applying policies that promote STE(A)M education. With this interaction, educators collaborate and learn (from) other educators and exchange STE(A)M-related experiences.

Within this area can be mentioned many of the recommendations due to the open and multilateral perspective of this area. Recommendation n.3 (the Community of Practice), n. 4 (Supporting cross-disciplinary synergies) and n. 8 (Policies co-design) are the perfect match with the nature of this area.

Educator as professional perspective includes all the required educators' competences related to their professional development alongside transferable and digital skills that are needed during STE(A)M-related activities.

Recommendation n.7 (Promotion of the competence framework), n. 8 (Development of a certificate for STE(A)M educators) and n. 11 (Raising awareness campaigns) aims and objectives are in line with this area of the competence framework.

6 Impact generated on policy

Through the project outputs, activities, and results, STEAMonEdu has provided to the educators' stakeholders Community of Practice a central role in designing, implementing, and assessing STE(A)M education policies. The great number and variety of aspects covered within have awarded the approach adopted by the consortium and it is in line with the European policies highlighting the relevance in supporting best-practices exchange and cooperation between stakeholders (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)248final).

Additionally, the digital environment of the Community has supported the development of the policies, and their understanding especially in terms of importance, showing an additional value in collaborating, peer learning exchange and get feedback.

The blended training programme has supported the reflection and challenge in elaborating policies and facing policy mindset at local and regional level for educators. The overall training programme and materials have further supported participants in the process of deeper digesting STE(A)M education following the aspects highlighted by European policies specifically focused on STEM and STE(A)M (EU SKILLS PANORAMA 2014, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (COM/2012/0669 final), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)247final, COUNCIL RECOMMENDATION of 19 December 2016 on Upskilling Pathways: New Opportunities for Adults, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)248final, Erasmus+ Programme Guide, COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning, (2018/C 189/01) Digital Education Action Plan (2021-2027), European Skills Agenda, European Education Area).

The STE(A)M educators' competence framework and the STE(A)M readiness SAT tool can be used to assess both educators and educational organisations throughout their adoption of STE(A)M approaches and leading the production of policies to support the STE(A)M adoption with peers as highlighted by many European policies promoting a lifelong learning educational mindset and upskilling scenarios for teachers (COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)248final, Digital Education Action Plan (2021-2027)), and focused on facilitating the development of an educational environment where the next generation can tackle the current challenges, in line with the Green Deal and Digital Skills Agenda, and also to support gender equality within education and, as a further impact, within the working environment (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (COM/2012/0669 final), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2017)247final, European Skills Agenda).